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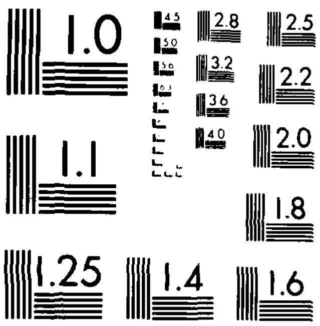

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

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THESIS

THE NAVTAG SYSTEM AND ITS MODIFICATION TO INCLUDE THE SH-60B HELICOPTER

by

Francis R. Goodwin

September 1984

Thesis Advisor: A.F. Andrus

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The Naval Tactical Game (NAVTAG) Training Systems are to become the standard war gaming computers in fleet use to train Surface Warfare Officers in tactical operations. As modern weapons platforms are developed, they need to be modeled into NAVTAG in order that they might be included in applicable at-sea engagements. In support of this objective, the SH-60B (SEAHAWK) Anti-Submarine Warfare Helicopter, which is currently

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This is a research project to determine if NAVTAG can be modified in a research environment and with what degree of difficulty this may be accomplished. This in no way is meant to modify the Standard NAVTAG Systems that have been distributed to fleet units without the consent of the Program Manager.

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The Navtag System and Its Modification to Include the SH-60B Helicopter

by

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Submitted in partial fulfillment of the requirements for the degree of

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from the

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ABSTRACT

The Naval Tactical Game (NAVTAG) Training Systems are to become the standard war gaming computers in fleet use to train Surface Warfare Officers in tactical operations. As modern weapons platforms are developed, they need to be modeled into NAVTAG in order that they might be included in applicable at-sea engagements. In support of this objective, the SH-60B (SEAHAWK) Anti-Submarine Warfare Helicopter, which is currently not supported by NAVTAG, is incorporated into the NAVTAG System. The SH-60B is incorporated into the NAVTAG System with the full range of functions that are enjoyed by other aircraft modeled in NAVTAG. Using NAVTAG the SH-60B is tested in an Anti-Submarine Warfare (ASW) scenario developed to test its capabilities against a Soviet submarine. For comparison and testing purposes the SH-60B is also compared to the SH-2F helicopter previously modeled in NAVTAG. Both helicopters have comparable mission objectives and tactics.

This is a research project to determine if NAVTAG can be modified in a research environment and with what degree of difficulty this may be accomplished. This in no way is meant to modify the Standard NAVTAG Systems that have been distributed to fleet units without the consent of the Program Manager.

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I. INTRODUCTION TO NAVTAG

A. HISTORY AND PURPOSE OF NAVTAG

The Navy realized that it had a deficiency in tactical decision-making training. To combat this situation the Chief of Naval Operations (CNO) issued a memorandum requiring a shipboard war game for tactical training 15 October 1980. The Naval Tactical Game (NAVTAG) Training System was originally a board game designed to simulate possible confrontations with various surface and sub-surface vessels. The NAVTAG Manual Game was thought to be an ideal candidate for shipboard war game tactical training. It was determined that due to observed shortcomings of the manual system which included a large quantity of documentation, umpire requirements, complexity, and slow speed of game play that automation was necessary. From this original requirement, the first delivery of automated, production NAVTAG units began October 1983.

NAVTAG was developed to reinforce the tactical knowledge already learned by naval officers and is not intended to be used as a tactical decision making aid or a TAO (Tactical Action Officer) trainer [Ref. 1: 1]. NAVTAG, to remain capable of emulating any possible engagement that might be encountered, must have the ability to allow new platforms entrance into the system. It is the intent of the Deputy Chief of Naval Operations to add to the master data base models only when systems are employed in at least 50 percent of a ship class.

B. OBJECTIVE IN CHANGING NAVTAG

The objective of this thesis is broken down into three distinct phases. The first phase deals with the study of the Standard NAVTAG System defined as an unmodifiable system. This system is currently issued to fleet units to prevent the NAVTAG Program from becoming fragmented. Once the Standard NAVTAG System is fully understood, the Full-Up NAVTAG System in the custody of the Naval Postgraduate School (NPS) will be studied and this begins phase two. In phase two the Full-Up NAVTAG System which allows modifications to be made to its data base will be utilized to incorporate the SH-60B helicopter. Phase 3, the final part of the stated objective, will be causing the SH-60B to be played in an original Anti-Submarine Warfare (ASW) scenario to allow comparison of its capabilities to its predecessor the SH-2F helicopter. NAVTAG's strengths and weaknesses will also be exploited and identified as the result of this phase of study. The results of this comparison will be made available to the Naval Training Equipment Center (NTEC) for study and analysis.

The SH-60B (SEAHAWK) Helicopter is expected to rapidly approach the 50 percent mark specified by the Deputy Chief of Naval Operations as a requirement for incorporation into NAVTAG. This thesis will lay the foundation for this incorporation. This direction of study is in no way intended as a means to circumvent the normal procedures for changing the standard NAVTAG Systems.

C. GENERAL OUTLINE

Chapter One contains the purpose, objective, general outline and goal of this thesis.

Chapter Two explains that the Standard NAVTAG System is an unalterable system to meet standardization requirements for equipment in use by fleet units. However to meet the requirement for additional platforms, rules, probabilities, and newer avionics and weapon systems, the Full-Up NAVTAG System such as the one possessed by the NPS can be utilized to modify the Navtag System to include the SH-60B helicopter.

Chapter Three gives a brief introduction into the Standard NAVTAG System and goes on to describe its components and features for general game play. NAVTAG's user friendly features and the manuals that accompany this system are also discussed.

Chapter Four's emphasis is on scenario creation and use. The nine preprogrammed scenarios and the option for user created scenarios are discussed. This chapter defines the meaning of 'scenario,' and explains how a scenario can be saved for future use. It also discusses limitations and rules that govern game play.

Chapter Five discusses the SH-60B specifically. Here the operating limitations, various performance characteristics, ordnance, and avionics gear that are found on the SH-60B are identified. Various parameters that affect how the aircraft and it's associated equipment should act once modeled in NAVTAG are also presented.

Chapter Six addresses the database design and the actual integration of the SH-60B into this database. Here the procedures for listing the SH-60B as the 41st aircraft in the Platform Selection Air Menu and associated sub-menus are explained. Here, the SH-60B is tested as a fully operational component of NAVTAG and related problems and possible areas for improvement are discussed.

Chapter Seven explains how the SH-60B and the SH-2F compare in the same scenario against a Soviet submarine. This chapter points out the differences in equipment, tactics, and applicable strengths and weaknesses pertaining to each helicopter.

V. THE SH-60B AND SH-2F HELICOPTERS

A. THE SH-60B AND SH-2F MISSIONS

The SH-60B has been designed to act as an extension of the ship's ASW weapon system. In support of this procedure, there are two separate operational modes that the ship and helicopter may utilize, Ship Control and Helo Control. Control in which shipboard personnel make tactical decisions which are implemented by the helicopter aircrew via the Date Link is the first mode. The second mode is Helo Control in which the helicopter aircrew makes all tactical decisions. NAVTAG can not make a distinction between these two modes. The SH-60B is a reactive system which prosecutes sub-surface contacts obtained from shipboard sensors or from other Battle Force sensors. With an endurance of over 4 hours in the ASW configuration, this helicopter is capable of several hours on station at the second and third convergence zones. The onboard processing and data link equipment are state of the art. Normal mission altitude will be around 7000 feet to maintain the line-of-sight requirement to maintain data link communications.

The SH-2F helicopter is the predecessor to the SH-60B. It is also an extension of the host ship's ASW capability and has been operating in this capacity for over 20 years. Once again this platform is a reactive vehicle that must be given information from ship sensors. This helicopter does have a data link but a limited amount of information can be passed back to the ship and this ability is also line-of-sight. Normal mission altitude is 500 feet in order to utilize the MAD to its maximum extent which sorely limits the distance over which the data link is effective. This

[Ref. 2: A-2] The rules in each area are extensive and try to reflect various conditions in a realistic manner. An example of one rule is that the maximum range at which surface ships and submarines could detect one another at night during bad weather is 1 nm. This is merely one small example of the extensive rules that cover each type of detection between different platforms utilizing various sensors under a wide variety of weather conditions.

environment to once again conform with expected or desired conditions. When modifying the environment such factors as weather condition, wind direction, layer depth, and convergence zones are set.

When building a scenario from menu selections, the only provided reference materials are the Characteristic Cards. Ship/Submarine Characteristic Cards may be used to list the capabilities of the platforms that will be used in the particular scenario. The General Situation, Tactical Situation, and Operation Order will have to be developed according to the intent of the scenario by the Game Director and/or Players.

D. SAVING A SCENARIO

To save a NAVTAG Scenario the Game Save and Restore feature must be utilized. This feature is available through the NAVTAG Executive Menu. This function permits the Game Director to save one or more game states and/or order records, restore a saved game state, manage the Game Save disk and set-up for the automatic saving or queuing of game states and order records. [Ref. 2: 5-5] The previous mention of order records refers to the saving of the actual orders that were input into the NAVTAG System. This feature allows the Game Director to later associate the commands given during game play to the events that transpired in a particular scenario.

E. RULES GOVERNING PLAY

Regardless of how the scenarios are developed, particular rules are enforced in NAVTAG to aid in realism. Rules, both probabilistic and deterministic, cover detection and effectiveness of visual sightings, radar detections, active and passive sonar detections, weapon acquisition, etc.

The General Situation provides background information which leads up to the current tactical situation and an overview of the general problem. The Tactical Situation states the specific tactical situation of the respective Blue/Red side, specifications of Blue/Red platforms and intelligence data relative to the opponent. The Op Order Extract is a summary of the contents of the respective Op Order. [Ref. 4: 1] Each ship involved in a scenario also has its characteristics listed in these manuals.

C. PRE-BUILT AND ORIGINAL SCENARIO CREATION

In most cases the pre-built scenarios are not going to be adequate to model engagements for which Tactical Officers need practice. For example, while preparing to participate in a real-world war game, NAVTAG could be used to model this situation and the applicable platforms. After the scenario was developed, the situation could be played repeatedly limited only by time constraints imposed by the impending exercise. Strategies could be compared, tactics compared as to how well they accomplished mission requirements, and experience on NAVTAG would certainly give the participants valuable practice in advance of real-world events.

To create an original scenario the System Initialization Menu needs to be called into operation and a three step process needs to be completed. First the composition of the Red and Blue Forces is determined and if a false target (merchant vessel) is desired then it is called into the scenario at this time. The second step allows the platforms to be taken one at a time to initialize them to the tactical specification. This includes positioning them relative to one another, assigning courses, speeds, and fuel states and also setting the launchers, radars, and other sensors to an on or off position. The last step is to modify the engagement to a full scale, multiplatform, multithreat operation.

The Game Director Guide is divided into a Red and a Blue Section and was designed to provide scenario information to the Game Director. It is divided into 2 sections, section one provides scenario information from the Blue Player perspective and section two from the Red player perspective. [Ref. 4: 1] This is obviously the primary reference guide to be utilized by the Game Director to gain an understanding of the Red and Blue missions. This allows the Game Director to evaluate the tactical decisions made by each player in light of their assigned mission. For example, Scenario One is a simple, yet typical example of the pre-built scenarios. Scenario One is defined as a surface versus surface confrontation. Each side is provided a specific Operation Order and information related to the General and Tactical Situation. Though both sides get the same type of information, they may start in different locations, have particular platforms with specific weapon and electronic capabilities, different intelligence reports, and their own perception of the facts relating to the situation. Such balancing between orders, facts, and intelligence reports provide the uncertainty which lend credence to a real-world situation.

The Blue and Red sides have individual scenario guides very similar to their respective segment in the Scenario Guide for the Game Director just described. The Blue Scenario Guide is a manual that supports the Blue player in conducting tactical simulations using one of the nine prepared scenarios provided with the system. [Ref. 5: 1] The Red Scenario Guide provides identical scenario information from the Red perspective. The Blue/Red Scenario Guides actually have the scenario descriptions broken into four sections including the General Situation, the Tactical Situation, Op Order Extract, and Ship Characteristics.

IV. SCENARIO USE WITHIN NAVTAG

A. THE NAVTAG SCENARIO

Scenarios are modeled tactical situations which may or may not reflect current tactical events. For the purposes of NAVTAG, a scenario is a situation that has been modeled to include selected platforms that have been defined within this system. Aircraft, surface, and/or sub-surface platforms make up both the Red Soviet and the Blue US/Allied Forces. These forces are prepositioned according to stated tactical considerations and desires of the Game Director. Each platform has capabilities determined by the fire control systems and associated weapons, guns, sonars/sonobuoys, and radars that have been defined as part of its respective equipment package. Environmental conditions also affect particular scenarios depending upon selected parameters which include water conditions, visibility, time of day, and layer depth.

B. PRE-BUILT NAVTAG SCENARIOS

NAVTAG comes complete with nine fully developed scenarios that are excellent representations of the various types of engagements a Surface Warfare Officer (SWO) might encounter. These scenarios are described in the Scenario Guide for the Game Director (NAVTRADEV P5077-1), the Blue Scenario Guide (NAVTRADEV P5077-2), and the Red Scenario Guide (NAVTRADEV P5077-3). These scenarios are designed to serve as initial tactical situations to build up expertise in NAVTAG and to use as possible models upon which individuals may build their own scenarios. The games range in size and complexity from a straightforward one-on-one surface

2. NAVTAG Reference Manuals

NAVTAG is also easy to use due to the detailed reference materials, designated "Courseware," that accompany the system. Realizing that various ships have a wide variety of design characteristics, engineering plants, weapons magazine storage space, and armament configurations, the NAVTAG package contains applicable reference materials which list this information.

These reference materials include Ship Characteristic Cards, NAVTRADEV P5078, which contain specifications for each ship and submarine modeled in NAVTAG. The Characteristic Cards are designed to be used as briefing and/or study materials. These cards contain a listing of a ship's sensor systems, combat systems, and propulsion systems on one side and line drawing profiles on the reverse side [Ref. 3: 9]. Personnel on a Perry class frigate would have only a marginal idea of the capabilities of a Spruance class destroyer and even less of an idea of the vital statistics of a Soviet vessel. An officer tasked to act as Commander of a Surface Action Group with such ships under his control might well study the Ship Characteristic Cards prior to actual game play. This would facilitate the realism that NAVTAG strives to emulate by having knowledgeable officers in control of ships.

Perhaps the most important NAVTAG reference manual is the User Manual, NAVTRADEV P5076. This manual provides a macro view of NAVTAG. The User Manual provides the user with information on how to set up NAVTAG, how to play as a Game Director, how to play as a Player, how to access the user lesson, how the NAVTAG equipment should be stored, how to do basic trouble shooting, and how to handle routine maintenance. [Ref. 2: 2-2] (very similar to the delays experienced in real life) of a minute or two and will not be functional until that time has elapsed. Course,turn, and speed changes, fire and search radars, and streaming towed sonar equipment are all handled in a similar fashion. Care must be taken when maneuvering ships and submarines are in close proximity of each other as they may collide and thereby sustain damage. Aircraft however have no collision features modeled in NAVTAG and may in fact pass through one another or a ship.

D. NAVTAG - DESIGNED TO BE USER FRIENDLY

1. NAVTAG is Easy to Use

NAVTAG was designed to be used by personnel with little or no programing experience. For this reason NAVTAG is operated by the use of menus, sub-menus, and prompts. This feature of NAVTAG is designed to confirm user entered commands by allowing the system to recover from mistakes. All of NAVTAG's features are reached by the use of these menus. For instance, to change the course of a specific ship, a ship is chosen from the Platform Selection Menu displayed on the respective team's terminal. A number is displayed next to each of a team's platforms and the user need only type in the number which corresponds to the platform whose course is to be modified. The Orders/Reports Options for Platform Sub-menu then appears on the terminal which allows the Movement Orders Sub-menu to be selected. From the Movement Orders Sub-menu the course of the designated ship can be changed with a numeric input which identifies the course change option. If a mistake is made on input it is a simple matter to alter because no information is processed until the player has left all menus and signaled that his turn is finished. NAVTAG is extremely straightforward to use and no programming or specialized computer knowledge is required or necessary.

game director will be utilized, and the selection or creation of a scenario begins play. One may choose from a diverse set of nine prepared scenarios which for example model Anti-Submarine Warfare, Anti-Air Warfare, Over-The-Horizon Multithreat environments, etc. or set up a scenario generated to reflect an upcoming tactical situation. Each of the preprogramed scenarios have a designated four letter name and may be called into play by typing this name and a corresponding game turn number in conjunction with provided provided prompts.

Once a particular scenario has been called into the NAVTAG System, the war game is installed and ready to play. Each side is free to expend as much time as the game director or the opposing side allows per turn. A turn consists of any number of modifications to a team's particular forces. When the desired modifications have been completed the player signals that he is ready through a keyboard command which effectively locks all modifications into a "turn." His particular terminal then goes into a wait cycle until the opposing player has signaled that he too has completed his turn. The Game Director then signals for processing procedures to start by a keyboard entry and his terminal processes the turn information input by each side. An assessment of conditions that have changed, such as ship positions and damage reports, takes place and then appropriate information is disseminated to both the red and blue teams. Each turn takes 1 minute of game time. This means that an aircraft going 120 knots per hour will move 2 nautical miles per move as long as that speed is sustained. The ships and submarines act in a like manner. Also in the interests of accuracy, NAVTAG provides equipment warm-up times. For instance, turning on a radar in a particular game turn does not guarantee that it will be available in the next game turn. Radar Systems have mandatory warm-up times

B. COMPONENTS OF NAVTAG

The Standard NAVTAG System consists of three semi-portable Wicat 150 WS Microcomputers. The Wicat Microcomputers each contain a MC 68000 processor and have a 1.5 Mbytes main memory capability. This system is interconnected with standard video and communication cables. One terminal is for the Red side designed to be the Soviet Forces, the second terminal represents the Blue side consisting of U.S. and Allied Forces, and the last terminal is for a Game Director who acts as a neutral referee. Inherent in the system is a lessons routine that allows the novice player to learn the proper NAVTAG commands and capabilities. The NAVTAG lessons routine will emulate a typical gaming sequence and present the various displays and commands This provides a user with hands-on practice at calling up the displays and inputting desired commands necessary to play NAVTAG. [Ref. 3: 8-9]. The versatility of this system allows one person to play against a computer directed side, one team to play against another team, and if desired a Game Director to officiate in either case. Also included in the standard package are two Master Data Disks which are classified secret and contain the routines, probabilities, and internal platform definitions and capabilities that are utilized by the NAVTAG System. The Master Data Disks contain all classified information required by the NAVTAG System and therefore are the only components of NAVTAG that must be treated as classified material.

C. PLAYING NAVTAG

To play NAVTAG only a rudimentary knowledge of the system is required. Typing the word "NAVTAG" and setting up the initial system parameters, which includes the number of sides to be played, a determination as to whether or not a

III. THE NAVAL TACTICAL GAME TRAINING SYSTEM

A. NAVTAG

NAVTAG was primarily designed to augment training in tactical areas for Surface Warfare Officers (SWO). NAVTAG tactical training has several implicit goals reflected in the following areas:

1. Operating Characteristics of major U.S., Allied, and Soviet ships, aircraft, and sensor, countermeasures, and weapon systems.
2. Sensor employment
3. Threat classification, identification, and target prioritization.
4. Selection of offensive/defensive systems.
5. Maneuvering and stationing.
6. Soft-kill/hard-kill defensive measures.
7. Firepower discipline.
8. Reassessment of threat. [Ref. 2: 1-4.]

Each of these tactical areas can be addressed in the particular scenario that is implemented using the NAVTAG System.

In support of these tactical training goals two objectives have been identified and supported by NAVTAG. The first objective is to help an officer become familiar with U.S., Allied, and Soviet ship and aircraft capabilities and their particular tactical considerations. In the process of meeting this objective, the officer would become better able to assess critical situations and make logical decisions to resolve them. The second objective is to make this learning and reinforcement process of tactical skills an enjoyable and mentally challenging game to promote its use. [Ref. 2: 1-1] system of the Full-Up System allows system modifications when proper routines are called into operation. The Full-Up NAVTAG System is held by the Naval Postgraduate School and will be used to support this project.

II. MODIFYING NAVTAG

A. NAVTAG AS A CLOSED SYSTEM

The Standard NAVTAG System can be considered a closed system in that the ships, submarines, and aircraft that are currently modeled can not be modified from their standard configurations. The parameters which govern platform performance are imbedded in the Master Data Disk. These parameters are isolated from the user through the operating system which does not allow the user to by-pass menus or prompts. The user is thereby restricted to merely picking menu selections or to answering prompts. Any deviation from the implicit domains of either the menus or prompts causes the same menu or prompt to be returned to the screen with an error message. This was accomplished to prevent the Standard NAVTAG System from being modified. This standardization of the NAVTAG System allows the Program Manager to maintain control over system integrity. The Program Manager is thereby assured that when he sends a NAVTAG change out to users, all systems will be affected in the same manner.

B. FULL-UP NAVTAG SYSTEM

Presently in NAVTAG there are forty different aircraft definitions that are supported and may be called to operate within a scenario. The variety of aircraft that can be modeled include jets, bombers and helicopters of both U.S./Allied and Soviet forces. To add an aircraft definition to NAVTAG it was necessary to obtain what is known as a Full-Up NAVTAG System. This system is very different from the Standard Systems that are delivered to fleet units. The important distinction between the two is that the operating

Chapter Eight addresses the possibility of adding other aircraft and/or ship platforms into NAVTAG in regards to practicality and ease of implementation. Recommendations and conclusions are listed as well.

D. GOAL

The goal of this thesis is to fully incorporate the SH-60B platform within the NAVTAG System. As such, the SH-60B will be able to perform it's ASW missions, maneuver according to its flight characteristics, sensor and detection gear will be operational, and information will be data linked back to it's host ship in a realistic manner. The SH-60B should act in a similar fashion to the other aircraft that are represented in NAVTAG.

helicopter has a mission time of 2.5 hours and this time is decreased by half an hour for each torpedo that is loaded up to its maximum number of two.

B. AIRCRAFT OPERATING LIMITATIONS

The biggest difference between the SH-2F and the SH-60B is in the area of performance. The SH-60B is a much larger helicopter that can remain on station longer, carry more weight, has higher performance engines, etc. than the SH-2F. The following paragraphs will document these distinctions since they will be carried forward into NAVTAG.

1. Aircraft Performance Characteristics

The SH-60B has a maximum airspeed of 180 knots and carries a maximum of 590 gallons of fuel. This fuel capacity gives the SH-60B a maximum range of 450 nautical miles and a maximum endurance rate of 4.4 hours. This helicopter has an average climb/descend rate of 1000 feet per minute (on a standard day) and can climb to a maximum altitude of 10,000 feet (pressure altitude). The maximum allowable angle of bank is 45 degrees and maximum gross weight is 21,700 pounds of which only 20,800 pounds are used for a standard ASW mission. Although these figures are accurate, assumptions have been made on a wide variety of variables including pressure altitude, outside air temperature, and helicopter weight to allow entrance into SH-60B performance charts. [Ref. 6: 4-32] Table 1 provides a listing of the performance characteristics of both the SH-60B and the SH-2F helicopters for comparison purposes. The SH-60B outperforms the SH-2F in all aspects with the exception of the climb/descent rate. This is due to the SH-60B being nearly nine hundred pounds heavier. Probably the most important factor is that the SH-60B can fly for about 4.4 hours on one tank of gas as

TABLE 1

SH-60B Performance Characteristics

Description	SH-60B	SH-2F
Engine Shaft Horsepower	1437	1350
Maximum Airspeed	180	150
Maximum Fuel Weight	4000	2500
Maximum Range	450 NM	230 NM
Maximum Endurance	4.4 Hrs.	2.9 Hrs
Climb/Descent Rate	1000	1200
Maximum Altitude	10000 Ft	10000 Ft
Maximum Bank Angle	45%	45%
Maximum Gross Weight	21700 lbs.	12,800 lbs.

compared to only 2.5 hours for the SH-2F. This allows the SH-60B to go out as far as one hundred miles and still prosecute a contact for two hours before it must return to its host ship. The SH-2F going out only 50 miles can stay on station only 1.5 hours.

2. Aircraft Ordnance

The SH-60B can carry up to two torpedoes as can the SH-2F. This figure is deceptive however as the SH-2F must take an auxiliary fuel tank off for each torpedo loaded on the helicopter decreasing on-station time by 30 minutes. The SH-60B carries two torpedoes as part of its ASW mission equipment as this load does not decrease its mission time of 4.4 hours. The SH-2F rarely carries any torpedoes because the fuel carried in the auxiliary tanks is so important to maintain time over a possible contact.

Up to 25 sonobuoys may be carried in the SH-60B's sonobuoy launcher at one time as long as the maximum load weight does not to exceed 800 pounds. A realistic load would be to carry 7 SSQ-62 DICASS sonobuoys which are active buoys that give bearings and ranges to a target and 18 SSQ-53 DIFAR sonobuoys which are passive and give bearings alone. It is obvious that with one SSQ-62 an accurate fix to a target can be obtained. With two SSQ-53's one could also get a fix by marking where the lines of bearing cross. Compare this with the capability of the SH-2F to carry only 15 sonobuoys. The buoys that may be carried are either the SSQ-41 LOFAR passive sonobuoys that report that they do or do not have a contact or the SSQ-47 Range Only active sonobuoy which gives bearings and if the Doppler signal is growing stronger or weaker. Clearly the SH-60B has a strong upper hand here.

The MK 84 Signal Underwater Sound Device (SUS) and the MK 25 Marine Location Marker can be carried onboard either helicopter. The number carried is dictated by the amount needed by the mission not to exceed the gross weight limitations. Both the MK 25 and the MK 84 have purposes as signaling and marking devices but are not to be considered as mission essential equipment under any circumstances.

Lastly there is an AN/ASQ 81 MAD bird (Magnetic Anomaly Detector) that is carried external to both helicopters at all times. Utilization of this system gives a distinct advantage to the SH-2F which flies low enough to utilize the MAD System to pick up submerged contacts. The SH-60B's normal operational altitude precludes the use of the MAD System as it is carried too high to pick up the changes in magnetic flux that a submarine makes when traveling through the water. However, this advantage is more than offset by the fact that the SH-2F data link, which is a direct line-of-sight device, is severely degraded at low altitudes. The SH-60B flying at altitudes of 5000 to 8000 feet can maintain a data link range in excess of one hundred miles. [Ref. 6: 8-3] Table 2 was developed to quickly compare the different ordnance carrying capabilities between

TABLE 2
SH-60B Ordnance

Description	SH-60B	SH-2F
Torpedoes	2	2
Mk 84	Weight Limited	Weight Limited
Mk 25	Weight Limited	Weight Limited
Sonobuoys	25	16
AN/ASQ-81 MAD	1	1

the SH-60B and SH-2F Helicopters on a standard ASW mission. The ordnance capacities can in some cases change by trading the weight of one ordnance for another.

3. Aircraft Avionics Gear

The important avionics capability for the SH-60b is to link information directly back to the ship. This is accomplished with the Radio Terminal Set, AN/ARQ-44. The Radio Terminal Set also called the Data Link System provides a highly directional super high frequency link between the aircraft and the ship. The Data Link provides for transmission of airborne sensor data (Radar, ESM, ACOUSTIC, IFF) to the ship and two-way transmission of computer and voice data. [Ref. 6: 7-50] At an altitude of 1000 feet this link which has a direct line of sight restriction will travel approximately 23 miles. [Ref. 6: 8-5] By increasing its altitude, the SH-60B helicopter can remain within the ship's line-of-sight to maintain its data link. The SH-2F sends only a limited amount of sonobuoy information back to the ship if it maintains its line-of-sight and is not considered to be very beneficial.

VI. INTEGRATION OF THE SH-60B SEAHAWK

A. NAVTAG SOFTWARE DESIGNED USING MODULAR CONCEPT

In order to include the SH-60B in the Air Platform Table it was necessary to first perform an intense study of the NAVTAG documentation to determine how this might be most easily accomplished. The most beneficial manual in this early stage of study was the Data Base Maintenance (DBMD) Document. This is the seventeenth volume of the nineteen volume Program Description Document set that was prepared by the SYSCON Corporation under contract to the Navy for the NAVTAG project. The DBMD's value is in the detailed design and description of the Data Base Maintenance Computer Program Component (DBM CPC) that it provides. This document was designed to be utilized by the programmer in coding and unit testing this Computer Program Component (CPC), and by maintenance personnel in future software support of the NAVTAG [Ref. 7: ii]. Contained within the DBMD is a complete listing of the modules that pertain to the creation and maintenance of the master data base from which data may be drawn in the creation of a NAVTAG Scenario.

1. Modular Independence

The description given in the DBMD shows that NAVTAG is largely based on concepts that are identified as software modularity. A module may be defined as being a separate addressable element that combines with other elements to make up a software program. A program that is designed with modularity as an objective has two very obvious benefits for software designers. First it allows many programmers to work independently of one another on the same program. They need only concern themselves with the information that must be passed back and forth between modules and not the actual structure or logic of each individual module. Another benefit is that when modular independence is achieved, an error in a particular module may be identified and corrected without fear of this creating a problem in other modules that make up the system program. In this phase of study, it was determined that the DBM CPC had almost complete modular independence. This was determined by studying the cohesion and coupling between modules which are considered to be effective measures of modular independence. Module independence is measured using 2 qualitative criteria: cohesion which is a measure of the relative functional strength of a module and coupling which is a measure of the relative interdependence among modules and the interface complexity between these modules. [Ref. 8: 161]

NAVTAG proved to have strong cohesion between modules. This could be seen when the study of modules showed that each performed either a single task or several tasks within a software procedure that were strongly related and required little interaction with other parts of the program. Modules therefore were designed to do essentially one thing. This same modular study showed that the modules displayed low coupling tendencies. Low coupling is desirable as a program's logic is restricted to modular entities and thereby easier to follow. Likewise, when a change is made in one module there is less chance of that change causing problems in subsequent modules. The high cohesion and low coupling observed in the DBM CPC led to the belief that changes in the NAVTAG software could be accomplished module by module without drastically overhauling the entire system.

2. Data Base Maintenance Computer Program Component

Further study revealed that the DBM CPC was designed to be an off-line support CPC. This support function meant that the DBM CPC was completely independent of the game initialization and game play portions of NAVTAG program. The DBM CPC is a stand alone CPC, neither invoked by nor invoking any other CPC. It is an interactive CPC available through the operating system alone. [Ref. 9: 3.23]. Therefore when accessing the DBM CPC, it is impossible to cause errors in other CPC's within NAVTAG as the programmer is prevented from changing the basic way NAVTAG works at this junction. The programmer when he wants to add, delete, or change a platform characteristic is gaining access into the tables from which the platforms are built. There is no reason then to alter the Fortran-77 language software that make up the procedures in the NAVTAG System. It was discovered that here, through the DBM CPC, the platform tables could be modified to include a new air platform class. The DBM CPC is designed to be responsible for building and maintaining the off-line data base used by the Game Initialization CPC to load platforms into an actual game. At this point it was clear that to add the SH-60B, an appropriate table or tables would need to be created utilizing the DBM CPC.

Leaving the DBM Document, the Program Performance Specification Appendices were consulted to find appropriate guidance as to data that needed to be searched for in the DBM CPC. Under Appendix A was a complete listing of the master data base tables that contains the static data pertaining to the characteristics, capabilities, and limitations of all platforms, sensors, launcher, and weapon systems which are required to simulated by the NAVTAG computer program [Ref. 10: A-1]. The Air Platform Data

Table (Table A-3) describes the characteristics, capabilities, and limitations of an air platform. Functionally, there shall be one copy of this table for each unique air platform in the data base [Ref. 10: A-7]. The Air Platform Data Table went on to describe that a maximum of 50 copies (air platforms) could be modeled in the NAVTAG System at one time. This appendix pointed out two crucial elements. First and foremost was that in order to add the SH-60B class of aircraft to NAVTAG, the class must first be defined within the data base. Second, only 50 classes could be represented in NAVTAG at one time which might necessitate the deletion of an older aircraft class. The Air Platform Data Table was also described in a general manner portraying the information that needed to go into the creation of a new class. The information that was included in this table consisted of items such as the maximum altitude and airspeed, the fuel consumption rate, the sonobuoy capacity, combat effectiveness factor, and data link type. To define the SH-60B class effectively in NAVTAG, these performance parameters had to be identified.

3. Incorporating the SH-60B into NAVTAG

In the DBM CPC there are over a hundred separate modules. Each of these modules have mnemonic names that allow the programmer to more easily track through the NAVTAG System. In the DBM CPC all of the modules start with "DB" and end with two to four additional letters. Some of these modules have very simple functions. For instance the DBYN module, when called, prompts the user for a "y" or "n" response. This value is then stored in a memory variable that will be called by a module that requires this user response. Other simple modules accomplish such tasks as clearing the entire screen, clearing the right half of the screen, and finding a null field. These modules will not be addressed in this discussion as they have no direct bearing on incorporating a new class of helicopter into NAVTAG. Therefore the exact path of this modification process will not be followed and the concentration of this discussion will be restricted to the major path which leads to incorporation of the SH-60B class.

To enter the DBM CPC a command file that is part of the NAVTAG operating system must be activated. This is accomplished by typing "DBM" at the prompt prior to entry into the NAVTAG System. This accesses the main module "DBM" which is represented in Figure 6.1. From this point there are three branches that may be taken. These paths allow a programmer to initialize a table, modify a previously defined platform, sensor, or launcher, or to modify the game rules that are defined within NAVTAG. The path that starts with the "DBGRMN" module deals solely with the game rules and need not be discussed since it has no relevance to stated goals.

Upon entry into the "DBM" module, the screen presents the user with 9 choices, the last being a way to terminate the update session. If an air platform has already been defined, options from this menu allow air platforms to be called up by either typing the class name or the associated number given to it by NAVTAG. The number that NAVTAG uses is really a key to a particular table defined on the Master Data Disk. Once a particular air platform data table has been called to the screen, any of its member data elements may be altered. This includes not only the helicopter performance parameters themselves but also the sonobuoys, platform sensors, and platform launchers with associated weapons. This is accomplished by going through the "DBUPUN" or update unit module.

The fourth choice presented by the "DBM' module is the "Update air platforms" option. If this option is

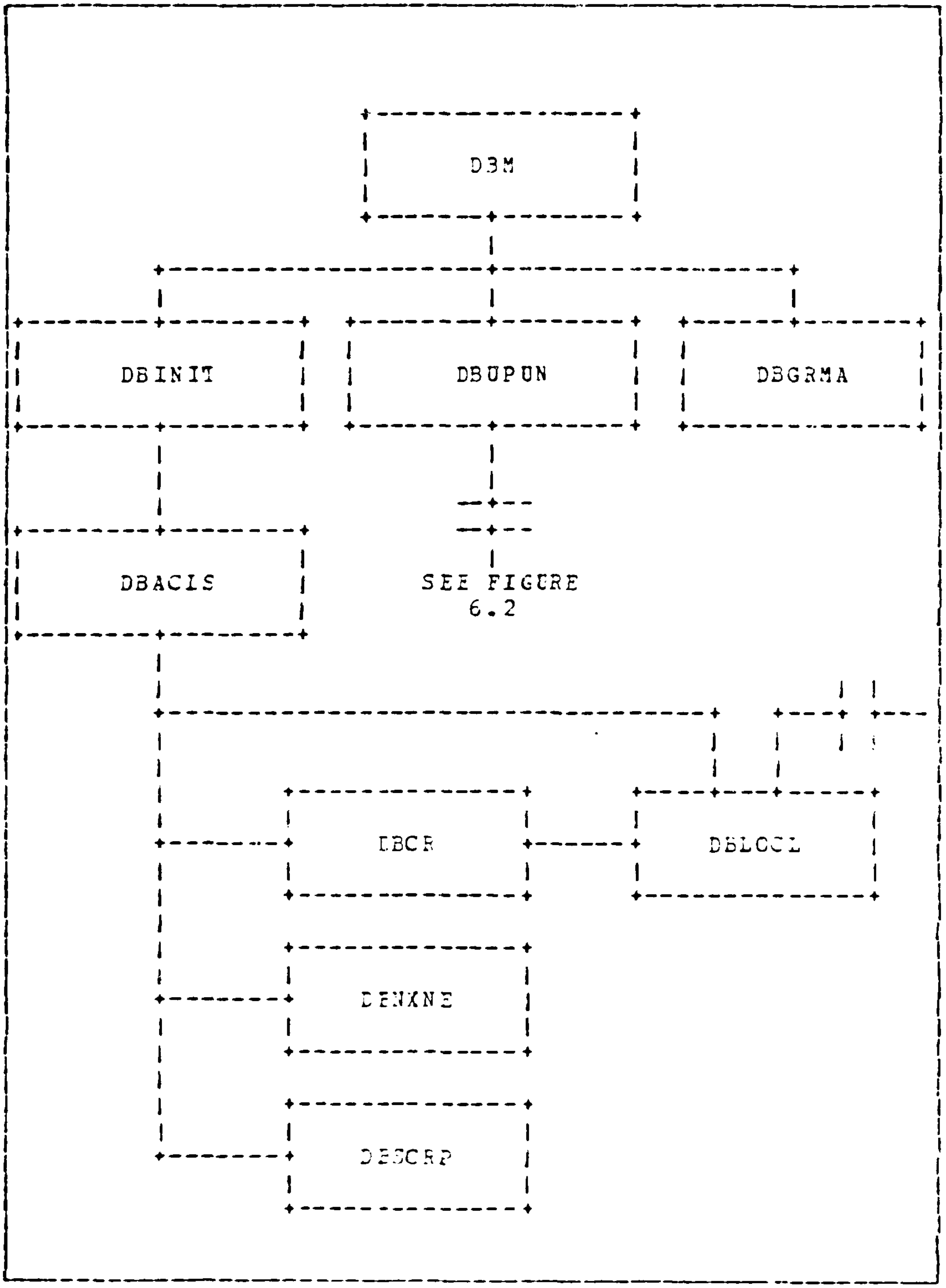

Figure 6.1 Module Structure to Define an Air Platform.

accessed, it allows the user entry into an area that controls the tables that are directly related to the air platforms. However, to define a class, we need to access "DBINIT," the intialization module. Since the air platform table has already been identified, through the "DBM" selection as the area of interest, "DBINIT" calls a generic air platform table into memory. When the user types in a class name within the 20 characters limitation, it is then appended to the newly formed table. The data that represents this new air platform class then proceeds to the "DBACLS" module where this air platform is actually added to the original listing of air platforms. Before a new class can actually be added into NAVTAG however, various modules perform checking functions. The "DBNXNE" module finds the first available position in the table for a class addition, the "DBCR" and "DBSCRF" modules prepare the screen at appropriate times for user responses, and the "DBLOCL" module searches through classes of aircraft that are already in the NAVTAG System. Should the user air platform class name be the same as one already listed among the Air Platform selections then the user is notified of this situation thereby preventing duplication of names. The new class that was actually input into the NAVTAG System was the "SH-60B." At this point "SH-60B" is an operable air platform in NAVTAG but is sorely limited in its capabilities. This is because the performance specifications are generic to air platforms and the correct sensors, launchers and sonobuoys need to be appended to the SH-60B at a later date through a different modular path.

When SH-60B class has been added, the user may then select the Air Platform Update menu option number one, "Display/modify by name." By typing in "SH-60B," the user may then proceed through the "SH-60B" Class, Sonobuoy, Platform Sensors, and finally Platform Launchers menus. This appends the SH-60B performance parameters, proper sensors and launchers, and the proper sonobuoy load to the SH-60B Air Platform Data Table. The transition from a generic helicopter to a helicopter that very closely approximates the actual performance and mission of a fleet SH-60B has been made. This transition is accomplished by starting at the Update Unit Module which then calls on the "DBDYMO" or Display and Modify Unit branch.

The "DBDYMO" module has a fairly complicated series of tasks that require 35 subordinate modules. The modules that will now be discussed are portrayed in Figure 6.2. By the use of pointers and memory variables that record user selections, any launcher, platform sensor(s), and/or weapon/sonobuoy data items may be adjusted to properly model a particular class selection. The SH-60B for example would never use the SSQ-41 Passive or the SSQ-47 Active sonobuoys that are still in use by the SH-2F. In order to append the proper sonobuoys to the "SH-60B" class, the "DBWSCG" module commonly referred to as the Weapon/Sonobuoy Change module is accessed through the "DBDYMO" module. This module allows access to any class of weapon or sonobuoy that is supported by the NAVTAG System. Since the SH-60B utilizes the newer SSQ-53 and SSQ-62 sonobuoys, both would be attached to the SH-60B class definition. "DBWSCG" checks to make sure that "SSQ-53 and SSQ-62" sonobuoy classes are valid selections before actually attaching them to the "SH-60B" class by checking the sonobuoy table for a listing of the same. The user may then allow up to a maximum number of sonobuoys that a class may carry and the number of each type that make up a standard load. The SH-60B for NAVTAG missions will start with 18 SSQ-53's and 7 SSQ-62's. The purpose and capabilities of these sonobuoys will be discussed in Chapter 7. This standard sonobuoy load has now become a part of the SH-60B definition. Should the SH-60B class now be called into a

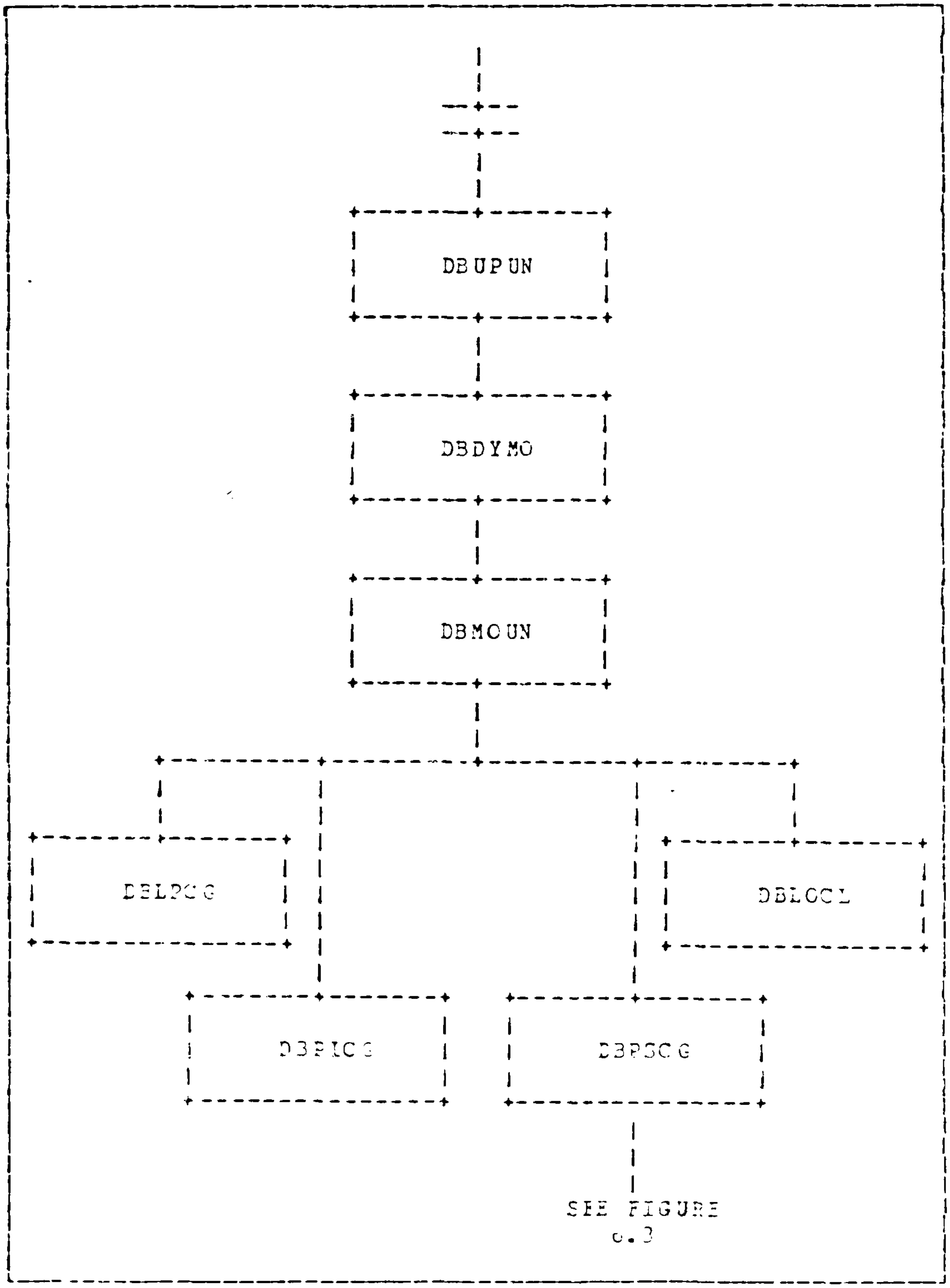

Figure 6.2 Module Structure for an Air Platform Class.

At the end of 45 minutes all 12 buoys had been employed. At this time the SSQ-47's were dropped around the submarines location. In turn 53 two of the three active buoys reported ranges to the submarine and a corroborating MAD contact was gained. In turn 54 the torpedo was launched on the estimated submarines position but NAVTAG reported it missed the target in turn 57. The helicopter was then out of fuel, sonobuoys, and weapons and was thereby forced to return to its host ship for replenishment.

2. Operational Problems with the SH-2F

The most notable problem with the SH-2F was the fuel/torpedo dilemma. The SH-2F is not able to adequately carry out a mission further than approximately 40 miles from the ship with sufficient fuel to prosecute a submarine contact. Even at this limited range, carrying two torpedoes isn't feasible. The scenario described above clearly illustrates that two torpedoes should be carried to give the crew an additional chance to sink a target but the fuel load isn't sufficient to support this need.

Another important problem was the limitation of the SSQ-41 and SSQ-47 sonobuoys. The SSQ-41's and SSQ-47's have been in fleet use for many years and have outlived their practical utility. Compared to the sonobuoys that are used in the fleet for contemporary submarine prosecution, they are seriously deficient. The number of sonobuoys that may be carried by an SH-2F is also a serious limitation. Within an hour of prosecution time all 15 sonobuoys had been used in the scenario described above. This was against a target that remained on a fairly straight course at a constant speed. A submarine knowing it was being tracked would have maneuvered to a much greater extent to rid itself of a pursuer. An evasive submarine would have required more sonobuoys to prosecute and the helicopter may have used all its sonobuoys before gaining a sufficient fix to launch its torpedo.

sunken ships, and temperature changes within the water. However in the NAVTAG environment only submarines can be detected by MAD equipment. In an actual fleet situation a MK-25 Smoke Marker, which is a pyrotechnic device that produces a marker of smoke where it falls into the ocean, would have been dropped. This is useful as no geographic references are available in the open ocean to mark a desired location. Although NAVTAG does not model the Smoke Markers, it does give a range and bearing back to the initial MAD contact for the following 10 moves. This feature for all practical purposes simulates the dropping of a MK-25. The helicopter was driven around this marker updated for the estimated course and speed of the submarine in the hopes of getting additional MAD contacts.

In turn 42 another MAD contact was gained and the first passive sonobuoy contact was gained. As previously stated, the passive sonobuoys give no range or bearing information. The objective in the use of the SSQ-41's is to get three or four buoys in contact. A fair approximation can then be made of the submarines location and then a MAD contact in this location confirms the location. In turn 46 it appeared that the submarine was almost out of the sonobuoy pattern so 3 additional buoys were laid in the submarines projected path. Very soon it became apparent that with the SSQ-41's alone it would be extremely difficult to trap the submarine. Due to the conditions of the water, some buoys further away reported contact while the nearer buoys never gained contact. With a buoy that reports only contact or no contact, it is extremely important that this information be consistent. The submarine was tracked for 45 minutes with the SSQ-41 buoys but another MAD contact was not forthcoming. More buoys would have allowed a faster and more accurate location but with only 12 passive buoys the consumption had to be balanced with time of prosecution.

altitude of this helicopter is 500 feet which allows it to use its MAD equipment while prosecuting a contact.

1. The SH-2F Mission

The ASW mission of the SH-2F is not to search a large area for submarines but rather to refine a solution that is passed to it by an air, surface, or sub-surface platform. The order was given to launch as soon as the P-3C passed its information to the ship. Since NAVTAG operates in minute step intervals, it was calculated that the helicopter needed to fly out a bearing of 090 for 27 minutes to cover the 60 mile distance that was reported to the submarine contact. This allows the helicopter to cover the majority of the distance, 55 miles, with the submarine proceeding in a reciprocal direction to cover the last 5 miles. Rather than accomplishing this time change turn by turn, NAVTAG's fast play feature was used to automatically advance the game 27 moves. On the 28th move, four passive sonobuoys were laid in a diamond-shaped pattern with a fifth buoy in the center.

Once the sonobuoy pattern was laid, the helicopter's speed was reduced to its standard ASW prosecuting speed of 70 knots. This speed is designed to allow the helicopter to monitor the sonobuoy pattern at a speed great enough to stay ahead of a submarine yet slow enough to maximize the usefulness of the MAD equipment. The sonobuoys once deployed, initially give no information while the hydrophones are deploying. This time is usually spent by the helicopter accomplishing MAD sweeps of the area within the sonobuoy pattern which should surround the submarine. This tactic was rewarded when 36 minutes after takeoff the MAD equipment picked up a submerged contact. In real life, without any other sensor corroborating this contact, it becomes a high interest point but is not assumed to be a submarine. A MAD contact can be caused by large concentrations of metal ore, helicopter is traveling at 120 knots with one torpedo then the round trip distance is 120 nautical miles. This constitutes 50% of the available flight time for the transit alone. This serious operational limitation can be overcome in one of two ways. First, if the submarine were closer to the host ship than the helicopter, transit time would be reduced. Secondly, the helicopter could carry no torpedoes and allow the ship to fire its torpedos should the submarine come within range. In both cases the obvious problem is that the host ship is too close to the submarine, which then may be able to fire at the ship. Nuclear submarines make more noise than diesel submarines and may be effectively tracked with passive sonobuoys. The SH-2F carries 15 sonobuoys divided between active SSQ-47's and the passive SSQ-41's. The tradeoff in the sonobuoy load is that the passive sonobuoy's information is not as accurate as that of the active sonobuoy but the passive buoy puts no detectable noise in the water to alert a submarine whereas the active buoy is immediately detectable. For these reasons it was decided to carry 12 SSQ-41's and 3 SSQ-47's on this mission to locate and track the submarine. Should an attack be required, then the active buoys could be employed to further pinpoint the submarine's location prior to weapon delivery for a more refined attack resolution. Another assumption made is that since the Perry has been ordered into a hostile area, the helicopter is to be placed on a 5 minute alert. This means that when the order is given to launch the helicopter, it can be launched within a 5 minute time span.

The environment of course is made up of many more variables than need be discussed here. However the weather has been identified as being good, the layer depth is 60 feet, and the bottom is composed of a hard surface 3000 feet down. These parameters allow the depth of the sonobuoy hydrophone to be set to its deep setting. Lastly the normal operational vessels yet in the local area. He has then decided to remain underwater for 12 hours (three hours still remain) before another surface and search is to be conducted. He is being extremely careful to remain silent to avoid possible detection by U.S. Forces which are expected to arrive at any time.

The mission as explained in the Red Side's Operation Order is to sink any American or Allied vessel. This is to be accomplished without being detected, identified, sunk, or captured.

The Red Scenario was designed to isolate the submarine from other Red Platforms. This was done in the interests of having a helicopter engage a submarine in a one-on-one confrontation.

B. THE SH-2F IN SCENARIO NUMBER 10

Various factors involving helicopter performance and readiness directly affect game play. In order to make a fair comparison between the two helicopters some assumptions will be stated at the onset of play.

The SH-2F has a listed maximum speed of 150 knots but in fleet operations the speed more commonly used is 120 knots. This speed enhances helicopter stability and allows the various helicopter ASW sensors to remain effective whereas a faster speed might cause excess interference in the equipment. The Tactical Situation requires that the prosecuting helicopter be able to engage the hostile submarine. This requires the helicopter to carry at least one torpedo. Recall that the 2 1/2 hour mission time of the SH-2F is reduced by 30 minutes per torpedo that is carried. If the submarine in question is 60 miles away from the base ship only one torpedo may be carried and still allow enough time to search for and localize a submarine. For example, if the in the art of ASW. The Perry will be relieving a P-3C aircraft that has been on station for 8 hours. The P-3C was unable to pick up any contacts until 30 minutes ago when a submarine was found but not identified. For the last half hour the submarine has been proceeding on a course of 270 degrees true from the Perry at a range of 60 miles. It also appears that this submarine has maintained a depth of 500 feet and a speed of 10 knots. The P-3C has also determined that this submarine is driven by nuclear propulsion.

The Operation Order given to the Perry's Commanding Officer is to stay well outside of submarine torpedo range. The Commanding Officer is also ordered to utilize his helicopter to locate the submarine and maintain attack criteria until a determination can be made of the nature of this submarine. If the submarine appears to be hostile or initiates an attack on any vessel it is to be engaged and sunk.

The Blue Scenario described above was intentionally designed to keep the helicopter's host ship away from the battle zone. This allows the helicopter to function without direct assistance against a submarine. This facilitates a direct comparison of the capabilities between the SH-2F and the SH-60B in the area of ASW capabilities since the ship will be the same for either the SH-2F or the SH-60B, and has no real impact on the ASW problem.

2. <u>Red Scenario Number 10</u>

The General Situation from the Red perspective does not differ significantly from that described in the Blue Scenario Number 10. However the tactical situation is very different. As Commanding Officer of a Soviet Echo II class submarine that has just sunk 5 vessels in a peacetime environment he must be aware that, once found, any mistakes may cause his ship and crew to be fired upon. After the last ship was torpedoed, a radar and ESM search revealed no U.S.

Side's descriptions explain the situation from that side's particular point of view. This means that even though the same world events are occurring, each side may have a different interpretation of what is happening due to intelligence reports and the frame of reference that are brought into the problem. Scenario 10 was created to mimic the scenario format of NAVTAG. Appendix A portrays the situation from the Blue perspective while Appendix B portrays the Red perspective. The intentional similarity of the two Appendices that describe Scenario Number 10 will allow this situation to be included in the Blue and Red Scenario Guides, NAVTRADEV P5077-1 and P5077-3, for future game play.

1. Blue Scenario Number 10

The situation that is facing the Blue side at mission start is described in Appendix A. The General Situation states that numerous U.S. and Allied vessels have recently been sunk in a remote area of the Mediterranean Sea close to the Zwentostoian coast. Although no one has yet claimed responsibility for these actions, Zwentostoe is a very likely candidate according to the Department of Defense. This feeling is caused primarily by the Zwentostoian statements of defiance and aggression in protecting its claimed territorial limit of 300 miles. The problem confronting the Blue side is that no proof against Zwentostoe has yet been presented and a big Battle Group could possible instigate third world nations in that area of the Mediterranean Sea into anti-American activities.

A U.S. frigate, the Oliver Hazard Perry, which is in this general vicinity is ordered to investigate this situation as stated in the Tactical Situation description. She has one helicopter on board (either the SH-2F or the SH-60B for comparison and evaluation purposes) that is well versed

VII. SCENARIO PLAYING WITHIN NAVTAG

A. PURPOSE OF SCENARIO NUMBER 10

NAVTAG is extremely valuable because of its scenario creation function. This will be demonstrated by setting up an ideal situation in which to examine the newly created SH-60B class and compare it to the SH-2F class. This situation will be designated as Scenario Number 10.

NAVTAG comes with nine preprogrammed scenarios. None of these are designed to test a helicopter's performance. Scenario Number 2 comes closest and for this reason it was used for the preliminary check of the SH-60B's integrated functions within the NAVTAG System. Scenario Number 2 includes three U.S. ships working against a Soviet submarine. The SH-60B class of helicopter can be assigned to one or each of these ships. However it was determined that a single ship would better emphasize the capabilities of the SH-60B. Therefore a single ship of the Perry class was utilized to provide a platform from which the SH-60B could data link, work, and refuel from during extended mission operations. The Perry class ship was purposely kept out of the ASW problem proper. It did provide support to the helicopter but did not actually become involved in the primary ASW search or tracking problem.

Scenario documentation was briefly described in Chapter 4. Both the Blue and the Red Sides should be given a description of the assigned mission before game play has commences. In following with NAVTAG's format, the scenario description should include a General Situation Description, the Tactical Situation, and an extract of the Operation Order. Both the Blue and Red as 2400 feet per minute. This rate was not identified to be either the maximum or the average rate of the SH-2F. However since no other climb or dive rate was mentioned within the Air Platform Data Table, it was assumed to be an average rate. Consulting the performance charts for the SH-2F it was determined that a much more accurate figure would be 1200 feet per minute and this figure has been incorporated into the definition of the SH-2F.

Not directly related to the NAVTAG program itself were the various utilities that are supported by the Full-Up System. One of particular interest was the copy feature which allows the Master Data Disk to be copied prior to any changes and allows restoration of the Standard NAVTAG features whenever desired. This proved to be extremely frustrating. Although a help feature and examples were provided, the copy feature could never be made to work properly. Commands to accomplish utility functions of this type were too long and impossible to follow. It was later learned that one must use a "mf" and "df" or mount and dismount floppy command respectively to tell the operating system to boot the disk drive. Additional documentation is obviously needed in this area.

clearly labeled. The on-screen prompts and menus also gave the user a domain that had to be observed. Any attempt to leave the stated domain caused an error message to appear on the screen and the user was given another chance for data entry.

When actually modifying the Air and Sensor Data Tables the most troublesome problem was attempting to discover the meaning of terms not commonly used within the helicopter community. For instance, fleet helicopter squadrons use the terms "loiter" and "buster" to mean circling around a general area and heading for a specified point at maximum speed respectively. NAVTAG had an additional term "gate" speed which is used by jet squadrons and had no real meaning in the modeling of the SH-60B. To resolve this discrepancy both gate and buster speeds were defined as being the helicopter's maximum speed. Problems of this sort were corrected by consulting the air community who could define the unfamiliar terms and then adjusting the probable values to reflect the true nature of the SH-60B.

Another problem was that although NAVTAG variable names were listed in their respective data tables along with the type (integer or ASCII for example), units, range (domain), and a short description of the variable mnemonics, it did not always explain the rationale behind the values. An apt example of this situation is the Combat Effectiveness Factor (CEFD) variable which rates an aircraft's effectiveness in a Dogfight. The range is given as 0 to 50. No indication is given as how to pick the correct value for a new air platform class. Problems of this sort were resolved by looking up the value given to the SH-2F and then, based on that number, assigning an upgraded or downgraded value to reflect the SH-60B capabilities.

One discrepancy did appear in the Air Platform Data Table. The climb/dive rate listed for the SH-2F was listed virtually every detail included in a scenario could be adjusted to represent the specific event desired by the Game Director and Players before game play started. Valuable experience was also gained in the use of laying sonobuoy patterns, checking sensor performance at various altitudes, and anticipating movements by and trying to track an enemy submarine, all of which portrayed the abilities inherent in NAVTAG.

With this experience and the SH-60B modeled in the NAVTAG System, it too was played in Scenario number 2. It performed in an extremely realistic manner in all aspects. The performance parameters enforced its maximum speeds and altitudes, sensors and launchers were located in the right numbers and locations with the proper number and type of weapons. The SH-60B was able to track the enemy submarine and lay sonobuoy patterns in the appropriate manner. The SH-60B was able to carry out its mission and communicate information with its host ship in a very authentic manner. The SH-60B had become the forty-first class in the Air Platform Data Table.

C. PROBLEMS AND DIFFICULTIES

Originally the Full-Up NAVTAG System was delivered without any documentation. The Standard and Full-Up NAVTAG Systems look identical without documentation to point out where the differences occur. The documentation is well organized and once delivered explained the exact structure and detail required to make changes within NAVTAG. However the documentation never described how to access the DBM CPC. However while searching through NAVTAG's on-line directory, a command file named "DBM" was discovered which turned out to be the key to the DBM CPC. Maneuvering between modules within the DBM CPC presented no problem since every step was a class of sensor. The sensor class, AQR-44, when first placed in the Sensor Data Table has general system parameters. It is up to the user to adjust these parameters to match those of the real AQR-44 system. NAVTAG has not been set up to model the AQR-44 data link which utilizes a Super High Frequency (SHF). This was not a serious limitation as the major feature of a SHF beam is that it provides an extremely directional beam. This could be mimicked with a Ultra High Frequency parameter which are also highly directional and can be modeled in NAVTAG.

B. TESTING AND RESULTS

The easiest way to see if the SH-60B was properly modeled was to run it in a scenario that is typical of its ASW mission and see if it performs in a realistic manner. Before testing the SH-60B, it was necessary to learn the actual characteristics of the NAVTAG System. Since the SH-2F is very similar to the SH-60B and since it was already modeled in NAVTAG it was the air platform that was used to initially play NAVTAG.

The SH-2F was used in ASWM Scenario number 2. This scenario pits three U.S. ships and a SH-2F against a Foxtrot Class Soviet Submarine. This scenario was ideal as it allowed the SH-2F to perform its primary mission of ASW with three supporting ships. This was valuable as it revealed how the helicopter and associated ships communicated and passed tactical information between one another while prosecuting a submarine. Game play with the SH-2F provided essential experience with the NAVTAG System and the characteristics that it exhibits during game play. The most interesting discovery was the ability to initialize the game scenario within NAVTAG. All platform characterist , platform locations, speeds, and directions, environmental conditions, and

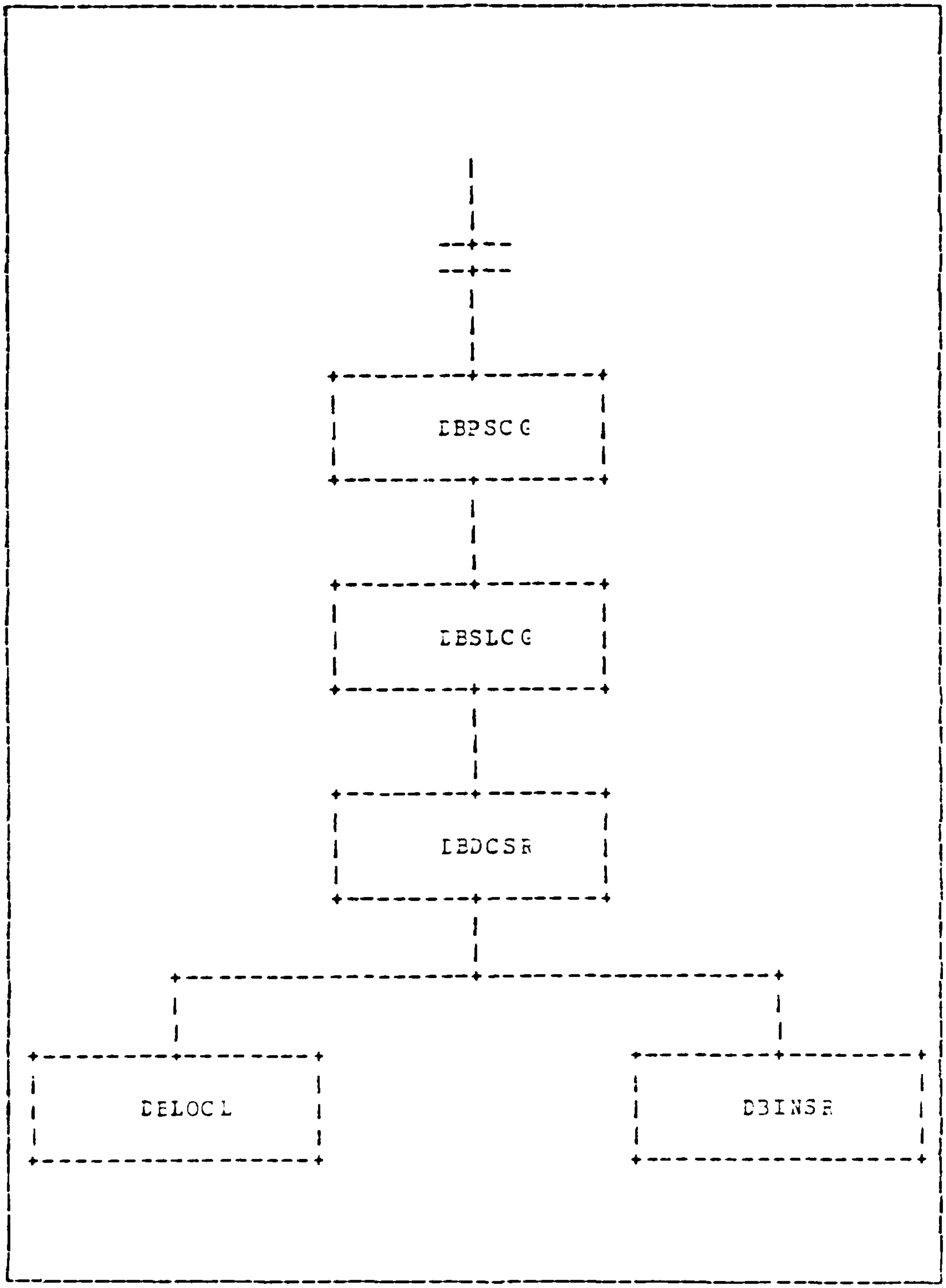

Figure 6.3 Module Structure to Define and Modify a Sensor.

scenario, the sonobuoy load associated with the SH-60B would be 18 SSQ-53's and 7 SSQ-62's. The Game Director could, through an initialization routine prior to game play, change the number of sonobuoys within each class that are carried by the SH-60B at mission start. However by defining the sonobuoys through the "DBWSCG" module the Game Director can only choose between the two types of sonobuoys listed for the SH-60B and in no case could the sum of the sonobuoys be greater than 18 plus 7 or 25. Through the "DBLRCG, DBPLCG, and DBPSCG" modules, slavable launchers, platform launchers and platform sensors may be changed respectively in a manner similar to the procedure for changing sonobuoys. The results of each module selection is also appended to the SH-60B class definition.

4. Addition of the AQR-44 Data Link

The only problem that was encountered when building the definition of the SH-60B was that the proper data link, the AQR-44, was not one of the sensor options that had been modeled in NAVTAG. Here the structure of the DBM CPC that addresses this particular problem is portrayed by Figure 6.3. Figure 6.3 shows the path that was taken to add the AQR-44 to the Sensor Data Table. This string was accessed through the "DBPSCG" module. The module that actually starts this modification is the Platform Sensor/Launcher Change module or "DBSLCG." The user would then proceed to the "DBDCSR" module and make a determination as to whether a sensor or a launcher is to be added or deleted. Adding a sensor will be accomplished with the aid of the "DBINSR" module. The "DBINSR" module is designed to not only insert a new sensor into the Sensor Data Table but also has several sub-modules which ensure that duplicate sensors are not admitted to the table and removes outdated sensor classes. The "DBLCCL" module works with the "DBDCSR" module to locate

A consideration that also must be investigated is how long it would take the SH-2F to replenish its supplies upon landing. In the previous scenario the enemy submarine knew it was being prosecuted as soon as the first SSQ-47 went into the water. Immediately an attempt would have been made by the submarine to elude the pursuer. Once successful, the submarine would have employed its own sensors to attempt to discover what had attempted to track it. A helicopter in the middle of the ocean is a dead giveaway that a ship is in the area. Since the submarine's primary mission is to destroy U.S. ships, it may very well decide to conduct a search for the helicopter's host ship when the helicopter has withdrawn. Once the host ship is found, it is very vunerable to attack while the helicopter, its main ASW sensor, is on deck refueling. The ship at this point would have to rely on its onboard sensors since both the P-3C and SH-2F are no longer providing this information. The helicopter would be on the deck of the ship a minimum of 30 minutes to refuel and take on sonobuoys and an additional torpedo. If the submarine decides to vacate its original territory, in 30 minutes enough distance could be covered to minimize the chance of a helicopter, with a localization mission, of finding this submarine again. At the very least the ship would have to assist in the prosecution exposing it to a possible torpedo attack which runs counter to its Operational Order.

The SH-2F has serious limitations in today's world of ASW. It is still able to prosecute submarines, but as shown in the NAVTAG scenario, these capabilities are limited in scope.

C. THE SH-60B IN SCENARIO NUMBER 10

The SH-60B also has performance and readiness conditions that need to be addressed prior to game play. The maximum speed of 180 knots is the speed used to get to a contact. Since the SH-60B's normal altitude is 5000-8000 feet depending upon how far it is operating away from the ship (the higher the altitude the farther the direct line-of-sight data link will operate). no sensors are affected by how fast the SH-60B flies. This higher altitude does decrease the effectiveness of the MAD equipment to such a negligible level that it will not be deployed on missions where the primary consideration is to pass mission data back to the host ship. Since the same scenario will be used for this exercise, the Tactical Situation remains the same.

The SH-60B is designed to carry two torpedoes for its ASW mission and remain airborne for 4 hours. The SH-60B can carry any type of sonobuoy that is maintained in the U.S. Navy's inventory. However, its 25 sonobuoy load usually will be divided between the SSQ-53 and the SSQ-62 type of sonbuoys. The SSQ-53 is a DIFAR buoy. It is a passive sonobuoy and gives a bearing to a contact. The SSQ-62 is an active buoy which gives both range and bearing to a contact. Here the same tradeoffs exist as with the SH-2F. As long as the passive SSQ-53 buoy is used, no detectable signal is put in the water as opposed to the SSQ-63 sonobuoy which makes use of an active signal that can easily be picked up by a submarine that is in the vicinity. When the SH-60B class was defined in NAVTAG it was given a sonobuoy load of 18 SSQ-53s and 7 SSQ-63s. This is consistent with the goals of this scenario. The enemy submarine is to be tracked covertly, therefore by passive sonobuoys, until such time an identification and/or surrender is demanded. Then the active sonobuoys will be employed for a refined location and a torpedo launch. This load also is within the maximum 800 pound limitation that is imposed on the SH-60B's sonobuoy launcher. The same environmental considerations are in effect for this scenario as expressed in the SH-2F example and the SH-60B is also placed in a 5 minute alert status. The P-3C has just passed information that a submarine has been tracked for the last 30 minutes and may be the hostile submarine that is of interest to the U.S. forces. The course, speed, and depths expressed for the submarine in the SH-2F scenario still apply.

1. <u>The SH-60B Mission</u>

The SH-60B's primary mission is to localize, track, and attack submarine contacts. As soon as the P-3C passed its information to the Perry, it was relayed to the helicopter which was immediately launched. The SH-60B traveling at 180 knots traveled 57 nautical miles in 19 minutes which allowed the reported submarine contact to travel a bit over 2 nautical miles. Again the fast play feature of NAVTAG was implemented to advance game play 19 moves and on the 20th move the SH-60B began to drop sonobuoys. Wishing to remain covert until such time as a firm track on the submarine could be established, the passive SSQ-53 sonobuoys were employed. Rather than trying to enclose the submarine in a pen of sonobuoys as the SH-2F did, the SH-60B attempted to maintain contact with three sonobuoys. Three sonobuoys, which give bearing information about a single contact, identify the position of this contact with sufficient accuracy to launch a weapon with a high degree of confidence. Initially the SH-60B used three sonobuoys instead of five and the information gleaned from these three sonobuoys is much more specific than that obtained by the SH-2F.

Specifically, the SH-60B dropped three SSQ-53 DIFAR sonobuoys during game turn 19. This helicopter then reduced its speed from 180 knots to the standard 90 knots used to monitor a sonobuoy pattern. Although at this time the helicopter could have descended from 6000 to 500 feet to employ MAD equipment, it was determined that the SH-60B assets would be better utilized if a 6000 foot altitude was maintained to continue to data link information back to the ship. The extremely slow climb/descent rate of 1000 feet per minute is an additional consideration that makes leaving a standard altitude very unattractive until a weapons launch is desired. During game turn 25 two of the SSQ-53s detected contacts which roughly corresponded with the information that was sent by the P-3C. In Game turn 26, the third sonobuoy also received contact via its hydrophone and with the three bearing lines a fix was established 26 minutes after takeoff. To model the nature of a submarine more realistically, the submarine started to take evasive actions as if it were trying to shake off possible pursuers. The submarine's maneuvers included speeding up from 10 to 15 knots, slowing down to 5 knots, making random turns, and sitting motionless. The SH-60B was able to follow all movements of the submarine maintaining a fix on its position at all times. When the submarine slowed extremely, the sonobuoys were unable to continue providing bearing information. The previous fix was accurate however and the submarine was moving away from that position at an insufficient speed to escape a torpedo if it had been launched. The helicopter toyed with the submarine for over an hour and only used 11 of its 18 passive buoys while retaining all of its more accurate SSQ-62s. From game turns game 26 through 86, at least two sonobuoys had contact on the submarine at all times. 64% percent of this time, sufficient information was available to drop a torpedo on the contact (three sonobuoys in contact).

At game turn 87 three SSQ-62s were dropped in a large triangular pattern around the submarine. Since the submarine had been taking evasive action an attack at this time was authorized. One SSQ-62 in contact with the submarine would have given sufficient information to determine an accurate fix on the submarine's position. However the triangular pattern made escape in any direction impossible and the helicopter could concentrate on accurate weapon delivery. The helicopter had to descend to a lower altitude to meet the launch envelope requirements for torpedo delivery while the hydrophones on the SSQ-62s were deploying. The helicopter followed the submarine's progress with the SSQ-53s for seven game turns at which time the SSQ-62s picked up the submarine. Game Turn 95 found the helicopter in an optimum release position for weapon launch. A MK-46 torpedo was dropped at this time and at Game Turn 97 the submarine was listed by NAVTAG as having sustained severe damage to hull, propulsion plant, and sensors.

A little over one and a half hours into the ASW problem the submarine was effectively sunk. This was accomplished with a reserve of 11 sonobuoys, 1 torpedo, and over two hours of on-station time. Clearly the SH-60B is a capable aircraft that is designed to search and attack submarines in an effective manner.

2. Operational Problems with the SH-60B

The SH-60B is designed to carry out ASW missions and does so in an admirable fashion. One problem that was noted in Scenario Number 10 is that to launch a torpedo the SH-60B must leave its operational altitude. This causes problems in that the host ship which has been following the ASW prosecution will lose the data link signal. This period of an ASW problem is crucial in order to determine whether the submarine was sunk or not and degrades the effectiveness of the host ship/helicopter submarine prosecution.

D. RELATIVE STRENGTHS OF THE SH-60B COMPARED TO THE SH-2F

While playing Scenario Number 10 with the Full-Up NAVTAG System, several major differences were noted between the SH-2F and the SH-60B.

The first distinction of the SH-60B is the ability to go far ahead of its host ship and feed back information that can be gainfully employed in a tactical situation. For instance, if a submarine is reported to be 100 miles ahead of a ship, the SH-60B can launch, drop sonobuoys into the water, and feed this information back to the ship while the ship is steaming to support the helicopter. In this case, even if the SH-60B fails to sink a submarine with its two torpedoes, the ship could be vectored into position to launch torpedoes of its own. The SH-60B, even without torpedoes, is deadly in that it can relay information to a ship platform out of the submarine's torpedo range which can then use this information to continue an attack against the submarine. This ship/SH-60B combination has an obvious advantage over a single submarine which can not detect a helicopter overhead or a ship that is out of sensor detection and torpedo range.

The SH-2F enjoys some of these same capabilities but to a limited degree. The SH-2F also works with a host ship but since the SH-2F's operational altitude is 500 feet the data link with the ship is often broken. This means that the ASW mission information must be fed to the ship over an UHF (Ultra High Frequency) voice channel. Since this mode of communication is not secure (can be detected and received by enemy sensors) this information is sorely limited in content. The pilots, while prosecuting the submarine solely from the SH-2F, are also limited in the amount of time they can transmit verbal information to the ship and maintain contact on the submarine.

The SH-60B was also found to have a plentiful supply of sonobuoys, ordnance, and fuel to carry out an ASW mission from start to finish as far as 100 miles. The SH-2F however was realized to be sorely lacking in this area. To carry out a mission outside of 50 miles of the host ship while carrying even one torpedo severely handicapped its possibilities of successfully prosecuting a submarine due to marginal on-station time. Equally as serious is the fact that 15 sonobuoys and a limited fuel capcity might make it necessary for the SH-2F to land for replenishment before the ASW mission is concluded. As previously mentioned, with the SH-2F on the deck of its host ship, the submarine could very well decide to initiate an attack at this time.

The SH-60B also takes advantage of the tremendous amount of ASW experience that is found on every ASW ship. The SH-60B, by sending all information back to its host ship, allows on board personnel to scrutinize data and advise the helicopter of the ASW situation. The SH-2F also sends ASW information back through its data link to its host ship initially. However this information is not transmitted during an entire ASW engagement as previously noted. This means that the Helicopter Aircraft Commander, the Assistant Tactical Officer, and the Sensor Operator in the back of the helicopter are trying to stay abreast of the entire ASW problem as well as flying the helicopter and informing the ship of what is happening over the UHF radio. This is a tremendous workload for the helicopter personnel and much of the valuable help of shipboard personnel is missed due to insufficient data being transmitted to their ship for processing.

Through the use of NAVTAG, it is clear that the SH-60B helicopter is extremely well designed for its primary mission of ASW. Though the SH-2F is still effective, it is effective in a truly limited sense.

VIII. AN OVERVIEW OF NAVTAG

A. PROBLEMS WITH MODELING THE SH-60B

The procedure for modeling the SH-60B was straightforward. The DBM off-line Computer Program Component was accessed by typing "DBM" and then menu selections appeared which guided a user through the various channels necessary to change the Master Data Base.

The major problem in modeling SH-60B helicopter in NAVTAG was in the area of platform rate documentation and the documentation that deals with variables. Although the reference manuals are excellent in their descriptions of general NAVTAG functions, capabilities, and special features, they do not describe the inner workings of NAVTAG. Two examples of this deficiency have already been presented in this thesis in the form of the Combat Effectiveness Factor - Dogfight (CEFD) Variable and the Climb/Dive Rate. The CEFD Variable has a numeric range of 0 to 50 with no explanation of where platforms should be classified given particular performance characteristics. The Climb/Dive Rate for the SH-60B was equally difficult to model because no explanation was given as to how this rate was developed or if it is a maximum or average rate.

The CEFD Variable and the Climb/Dive Rate are two examples that represent an entire class of possible misinterpretations that can occur in NAVTAG. Nowhere in either the Standard or Full-Up NAVTAG System documentation are the issues of definition addressed. When trying to modify the NAVTAG System, there is no accurate method that may be used to guide the creation of a platform through the maze of variables in order to keep NAVTAG consistent in its definitions. As more platforms, sensors, and launchers are added to NAVTAG this inaccuracy of these variables and rates will become more apparent in degree of accuracy with which NAVTAG is able to model various equipment that is modeled in the Master Data Base.

Problems of a smaller magnitude were also discovered when modeling the SH-60B. When trying to implement the SH-60B AQR-44 Data Link, it was noticed that NAVTAG does not support Super High Frequencies (SHF). The main difference between SHF and UHF is that the SHFs are much more directional in nature. Although NAVTAG could not specifically model the SHFs, NAVTAG could be "tricked" into acting as if a SHF beam had been modeled. When setting up a scenario, the SH-60B needs to be assigned to a host ship by listing the ship as the controlling unit. NAVTAG is designed to always have an air platform's sensor information go to the controlling unit and only to that controlling unit. Hence a directional data link is modeled. However this procedure caused NAVTAG to disseminate *information*, through its Link 11, to all ships in a battle force. This initially presented a problem since information passed from the helicopter to its controlling ship was then being passed to the entire battle force, which is not the way a SHF beam works in real life. To circumvent this deficiency, both the controlling ship and the SH-60B's data link were put in the "receive only mode." Since the ship was restricted to receiving data, it picked up the helicopter's information but did not transmit it out to other ships through its Link 11. The SH-60B, also in the "receive only mode," was able to receive ship's information but did not have to transmit to the ship since the controlling ship always gets this information. Hence a SHF "imitation" was installed into the NAVTAG System.

E. GENERAL PROBLEMS IN NAVTAG

Probably the most notable discrepancy within NAVTAG was that when a torpedo was added to the SH-2F for scenario play, it did not cause a corresponding 30 minute decrease in the amount of fuel that could be carried by this platform. This is an obvious error that fails to capture a major limitation of the SH-2F. The reason that this factor was overlooked is probably because this is a problem unique to the SH-2F and not air platforms in general. It would seem likely that other air and surface platforms that have unique requirements as compared to general platform design characteristics might also have been missed.

As stated in the body of this work, the data link that is the communications equipment that ties the ship to the helicopter is line-of-sight due to the super and ultra high frequencies that are used. In scenario play, both the SH-60B and the SH-2F were able to maintain their respective data links at an altitude of 500 feet out to a range of 170 to 210 miles. This is an obvious mathematical flaw in the calculated range over which a data link can be maintained between ship and helicopter.

Another point of confusion is the software mechanism that allows weapons to be fired. Once the ordnance and launcher to be fired have been identified, a menu prompt appears that asks "F to FIRE?" This seemed to say that if the missile or gun launcher has been given a range and bearing on which to fire, then an "F" should be typed. What isn't expressed is that if any other weapon is to be fired in that particular game turn, then the "F" should not be typed until all weapons orders have been set. The documentation does state that once any launcher has been told to fire that this command locks out any further fire commands during the present game turn. However this is not obvious during game play.

There are six different sonobuoy versions that are modeled in the NAVTAG System. All of them appear to be properly defined regarding the type of information that they should pass and the probabilities of detection that are identified in the probabilistic and deterministic areas of NAVTAG's Master Data Base. However the time it tock for the sonobuoys to start relaying reliable information to the helicopter seemed extremely long. This real time delay is caused by the time it takes for the hydrophone to deploy to its preset length. Once the sonobuoy hits the water, no information is passed until the hydrophone has fully stabilized at depth. The time that NAVTAG allocates for this process seems to be inordinately long when compared to experiences of sonobuoy use in the fleet. The routine that determines this time may be in error.

A problem discovered while trying to model the SH-60B most likely occurs in most platform types modeled in the NAVTAG System and deals with the definition of variables as integer types. The loiter fuel consumption (LFUELR) and buster fuel consumption (BFUELR) rates were determined to be 1.2 and 1.7 pounds / minute / 10 respectively. Since the LFUELR and BFUELR variables were identified as integer types however, trying to represent the values 1.2 and 1.7 resulted in an error message. To circumvent this inaccuracy, the LFUELR was rounded down to 1 and the BFUELR was rounded up to 2. NAVTAG represents variables in only two ways, either as an integer or an ASCII string with a defined maximum length.

The last two problems that were discovered in NAVTAG deal with the aircraft platforms specifically. The first is that an aircraft may fly with zero airspeed. This of course is realistic when dealing with helicopters, but propeller and jet driven aircraft also stay aloft in the NAVTAG System with no airspeed which is a physical impossibility. The second problem deals with NAVTAG not recording aircraft mid-air collisons. Too many aircraft prosecuting the same ASW contact could result in a collison and this fact should be modeled into the NAVTAG System.

C. RECOMMENDATIONS FOR NAVTAG

The recommendations for the NAVTAG System are broken into two different categories. The first category deals with studies of how NAVTAG mathematically models certain physical phenomena and the second deals with changes in the actual coding of NAVTAG.

NAVTAG seems to have represented both the time it takes to deploy the hydrophones on sonobuoys and the range at which the data link remains operative in an inaccurate manner. The deployment of hydrophones takes approximately three minutes in actuality while NAVTAG represents this fact with a time duration of 7 minutes. The data link, which is a line-of-sight device, remained operational to distances of 170 to 210 miles at altitudes down to 500 feet. In both situations, NAVTAG is presenting the user with information or delays that are not indicative of what really happens when these devices are utilized. The formulas that are used to calculate both the deployment of a sonobuoy's hydrophone and the range at which the data link continues to operate, need to be investigated and corrected to properly emulate realistic capabilities.

The second series of recommendations require coding changes within the NAVTAG System's Fortran-77 coding. First the frequency range that NAVTAG can model needs to be expanded to include SHFs. Since these frequencies are now being used and allow secure communications to exist between two platforms, it will be placed on more of the newer naval vessels that are being build. The method of putting both the ship and helicopter worked only because the ship did not require its Link 11 to pass information to other ships. If more than one ship had been used in Scenario Number 10, then the SEF data link could not have been modeled.

Presently NAVTAG allows only submarines to trigger the MAD equipment. This presents a false picture to the user as the MAD equipment will detect any aberration in the earth's magnetic field. Here the coding could generate 1 percent of total MAD detections as being false. This aids NAVTAG's tactical training objective by allowing users to decide, based on tactical information, whether or not the detected MADs result from a submarine's presence.

Each modeled platform in NAVTAG should be carefully reviewed for possible unique characteristics that are particular to one class (aircraft, surface, sensor, etc.) and no others. Unique characteristics are harder to model in NAVTAG due to their large numbers. However this situation could be modeled by using a module specifically dedicated to adding unique characteristics when a class is constructed. Since this step may be cost and time prohibitive, perhaps a quick way to deal with this situation is to provide an appendix to the user manual. In this appendix each unique characteristic could be documented so the user would realize the artificialities that are introduced into game play.

The way weapons are fired should also be changed in NAVTAG. Rather than having one fire command launch and firing all weapons during one game turn, the coding should be changed so that each launcher and gun is fired by individual fire commands. This would alleviate the problem of users pushing the fire command during a game turn and locking out changes in these fire orders before the turn is actually finished.

NAVTAG should be able to model aircraft collisions. When an aircraft has the same location and altitude as another, then a notification should be presented to the user that a mid-air collison has taken place. Rather than stopping game play at this point, the Game Director would have the option to continue game play or terminate the air platforms involved in the collison.

The next recommendation deals with the way that platform variables are represented. Figures and rates that are modeled in NAVTAG should have the ability to exist as real numbers depending upon how much variance exists in the possible range of these numbers. Variables like fuel rates are extremely important in tactical mission planning and should be accurately represented as real numbers in NAVTAG.

The last recommendation deals with the maintenance of aircraft in NAVTAG. NAVTAG seems to deal with maintenance indirectly by requiring all helicopters to remain on the deck for a minimum of 30 minutes. This method of enforced maintenance should be changed. Although this is the time required to refuel and accomplish routine maintenance for the SH-2F, it does not address the fact that the SH-2F must remain on the ship's deck after 10 hours of flight time for maintenance of a longer duration. The SH-60B is penalized because it must remain on the host ship for 30 minutes even though it is able to maintain flight operations around the clock. The NAVTAG Program Code should be modified to account for the time that must be spent on an air platform's maintenance. This could be accomplished by adding a variable that would be adjusted for each particular class. This variable should be broken in two parts. The first part would deal with the time it takes an aircraft to refuel and load ordnance and the second would take into account the time that must be spent on ground maintenance to keep the aircraft flying.

D. OBJECTIVE RESULTS

1. Phase 1

The Standard NAVTAG System is beneficial for its intended purpose of training Surface Warfare Officers in tactical matters. However NAVTAG should not be restricted to use within the surface community. Since the U.S. Navy integrates the surface, air, and subsurface platforms, to combine capabilities in order to successfully carry out mission objectives, NAVTAG should be used by fleet units for integrated training. This is feasible in shore training facilities where tactical training is not restricted to segregated communities and on ships that have air detachments assigned.

On air capable ships, this can be accomplished by allowing the Red or Blue sides to be made up of participants representing the air and surface concerns. Not only would valuable tactical training be accomplished in a relatively inexpensive environment but cross training, providing a more accurate perception of different platforms, would be attained by all participants.

2. Phase 2

The SH-60B, as well as other air platforms, surface platforms, subsurface platforms, sensors, launchers, and weapons may all be modeled in NAVTAG with relative ease. A problem exists in the control and accuracy of the data that is inserted. This point was observed with the inclusion of the SH-60B in the Air Platform Database. Since no documentation exists to detail variable definitions, some of the numbers used to model platform parameters may be inaccurate. If the Program Managers meticulously documents variable definitions and changes made to the NAVTAG System, then the various platform variables changed in the future would be done in a consistent manner. The Full-Up NAVTAG System and its use should be restricted to the NAVTAG Program Manager and to those interested in research that examines NAVTAG's strengths, limitations, and possible enhancements. The Full-Up System could, in general use, cause indiscriminate modification of NAVTAG. This would lead to serious control problems for the NAVTAG Program Manager causing different versions of NAVTAG to exist with no standard "NAVTAG."

3. Phase 3

The nine programmed scenarios that come with the NAVTAG System are valuable learning tools. These scenarios show the wide range of modeling parameters that may be adjusted to display virtually any situation. It is important that the system users realize that the true value of NAVTAG resides in its flexibility to model specific scenarios that may be encountered in fleet operations. For this reason, it is strongly recommended that the users of the NAVTAG Systems create their own scenarios. Platform capabilities and tactics will be learned as well as the specifics that may occur in war games and scheduled exercises. Scenarios are capable of being modeled for any imaginable situation as long as the platform classes are available in the data base. Scenarios are not limited by the number of platforms that may participate at one time.

Users must be aware that as the number of platforms increase in a scenario, the response time increases in a corresponding manner. When the Blue and Red sides each had a battlegroup composed of 10 platforms, the response time for each turn changed from approximately 15 seconds (for two platforms per side) to an average of 9 and a half minutes. Although this extended time can be somewhat annoying, when ten ships are being controlled this time is needed to prepare for ship maneuvering and strategy development.

As a new scenario is created, the documentation should be saved in a binder for future reference. This creates a NAVTAG Scenario library to augment future game play.

E. CONCLUSION

NAVTAG was designed to help teach tactics to Surface Warfare Officers. It has been shown that NAVTAG can also be used to teach tactics to pilots which includes areas such as the proper deployment of a helicopter and the consequences that result from decisions when acting against a particular class of submarine. Another very important facet of NAVTAG is that it helps facilitate tactical coordination between pilots and surface officers. This can be a tremendous advantage in the early stages of integration when an air detachment is first deployed on a new ship.

APPENDIX A
BLUE SCENARIO NO. 10 (ASW)

General Situation

Recently, there have been numerous military and commercial USA/Allied ships torpedoed in the Mediterranean Sea. No one has claimed responsibility for these hostile actions though much unrest among the third world nations in this area has been noted. Rumors around the United States Department of Defense feels that the small country of Zwentostoe is a probable candidate.

Zwentostoe is a small coastal country that has recently been very vocal in its opposition to the U.S. Government Policies which they state are "imperialistic and designed to maintain the capitalistic governments in power at the expense of the smaller nations." More than once Zwentostoe has claimed that its territorial waters extend to 300 miles and that it is willing to protect this right with any necessary force.

The U.S Government is not willing to send a Large Battle Group into this area as this could incite militant third world nations that surround Zwentostoe into other acts of aggression against the U.S.

Tactical Situation

Shortly after arriving in the Mediterranean Sea, the Commanding Officer of the O.H. Perry was ordered to rendezvous with a P-3C aircraft that has been on-station for 8 hours and must depart due to low fuel indications.

The P-3C has located an unidentified submarine about 30 minutes ago whose present location is 270 degrees true from the Perry at a range of 60 miles. The submarine has not surfaced since it was detected and the speed has been a steady 10 knots. The P-3C was also able to determine that the submarine has a nuclear propulsion system.

It appears that no other ships are in the area either surface or submerged.

OP Order (Extract)

THE C.H. PERRY IS DIRECTED TO UTILIZE HER SH-2F/SH-60B HELICOPTER TO LOCATE THE THE ENEMY SUBMARINE THAT HAS BEEN ATTACKING U.S. VESSELS. THE PERRY IS NOT TO CLOSE WITHIN SUBMARINE TORPEDO RANGE. ONCE THE ENEMY SUBMARINE HAS BEEN LOCALIZED AND IDENTIFIED AS BEING HOSTILE, ATTACK CRITERIA IS TO BE MAINTAINED WHILE A DETERMINATION CAN BE MADE AS TO THE INTENT OF THE SUBMARINE. THE SUBMARINE IS TO BE GIVEN WARNING THAT IT IS TO IMMEDIATELY SURFACE TO BE IDENTIFIED. IF THE SUBMARINE TAKES ANY ACTIONS THAT CAN BE CONSTRUED AS HOSTILE OR SHOULD IT TRY TO TAKE EVASIVE ACTION IT IS TO BE ENGAGED IMMEDIATELY.

APPENDIX B

RED SCENARIO NO. 10 (ASW)

General Information

The country of Zwentostoe and the surrounding nations have been very critical of the U.S. on several important issues. For several months these disagreements have erupted into serious arguements with the Zwentostoian ambassador to the U.N. threatening to take severe action if its rights were ignorred.

Just after the Zwentostoian Ambassador threatened to take action against the U.S. a submarine appeared in the general vicinity of Zwentostoe and started sinking vessels friendly to the U.S. World opinion has assumed by that this unknown submarine is Zwentostoian and is retaliating against the U.S. which refuses to acknowledge a 300 mile Zwentostoian territorial limit. Several nations that surround Zwentostoe have lent vocal support to these acts of aggression against the "imperialist persecution" of the U.S. The Zwentostoian President has refused to comment.

Tactical Situation

You are the Commanding Officer of a nuclear Soviet submarine of the Echo II class. Present course 091 degrees true, speed is 10 knots, and depth is 500 feet. You have sunk 5 ships in the last two weeks and have given the allowed the crew to stand down from "red alert" as no additional ships were detected to be in the immediate area. No sensors are on at this time in the attempt to remain undetected while the crew is getting some much deserved rest. In three hours you plan on raising ESM gear and possible coming up to periscope and radar depth to sanitize the area. No intelligence has been received for two weeks in conjunction with the desire to maintain radio silence but Blue forces are expected to arrive any day now.

OP Order

INTERCEPT AND DESTROY ANY BLUE TARGET OF OPPORTUNITY. YOU ARE DIRECTED NOT TO BREAK RADIO SILENCE AND UNDER NO CIRCUMSTANCES ARE YOU TO ENGAGE SUPERIOR FORCES. YOU MUST NOT BE IDENTIFIED AS A SOVIET COMBATANT OR BE CAPTURED.

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7. Data Base Maintenance Program Description Document, D-A006-17-A, Naval Tactical Game (NAVTAG) Training System, 14 June 1983.

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